Business Case For Electrically Safe Design Of Facilities

- Electrical hazards cause a workplace death almost every day.[1]
- Between 2003 and 2009, contact with electric current was the seventh leading cause for an occupational fatality.[2]
- Although not in the top ten causes for workplace injuries costing industry $51.1 billion in 2010, electrical burns are the second most costly injury.[3]
- Medical and disability costs for electric injuries can be astronomical. For example, total costs for one case were over $12M, and direct costs in the year of an electrical injury were $150,000 to $370,000.[4]
- In a five year study, electrical injuries were <2% of total number of injuries in the electrical worker population examined, but contributed between 26 - 52% (depending on which year) of the total worker injury costs for the utility involved.[5]
- Washington State research showed about 10% of all serious burn injuries occurring at work were caused by electric arc/blast explosion.[6]
- Specific research into savings is lacking for different electrical design options for reducing workplace injuries. However, analogous information may be obtained from different research involving injuries from electrical hazards, and cost savings from workplace safety and occupational health programs.
- A survey of senior management showed the benefits of an effective workplace safety program were to increase productivity 42.5% and reduce costs 28.3%, every $1 spent on direct accident costs resulted in $3 to $5 of indirect costs, and for every $1 spent on safety, savings were at least $3.[7]

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[1] Electrical Safety Foundation International (ESFI): http://www.esfi.org/index.cfm/page/Electrical-Safety-in-the-Workplace-Fact-Sheet/cdid/10619/pid/3003.

[2] ESFI retrieved from: http://www.esfi.org/index.cfm/pid/10272/cdid/11512.

[3] Refer to: Liberty Mutual Research Institute for Safety, 2012 Workplace Safety Index, and J Occup Environ Hyg. (2009), *Etiology of Work Related Electrical Injuries*: http://www.ncbi.nlm.nih.gov/pubmed/19626529; Lanny Floyd 2013 IEEE presentation, *Advances in the Practice of Electrical Safety*: http://sites.ieee.org/northern-canada-pesias/files/2013/04/Advancements-in-the-Practice-of-Electrical-Safety-13-May-2013-rev-1.pdf ; and *Thermal burn and electrical injuries among electric utility workers*, 1995-2004: http://www.ncbi.nlm.nih.gov/pubmed/17116371.

[4] New York Academy of Sciences, *Health Implications of Global Electrification* (1999): http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1999.tb07936.x/abstract?systemMessage=Wiley+Online+Library+will+be+disrupted+on+31+August+from+10%3A00-12%3A00+BST+%2805%3A00-07%3A00+EDT%29+for+essential+maintenance&userIsAuthenticated=false&deniedAccessCustomisedMessage.

[5] Ibid

[6] Washington State Department of Labor and Industry *Burn Injury Facts* (April 2006) retrieved from: http://www.lni.wa.gov/Safety/Research/Files/ArcFlashHazardReport.pdf.

[7] ASSE Professional Safety (April 2009) *Financial Decision Makers' View on Safety*: http://www.asse.org/practicespecialties/bosc/docs/F2_Huangetal_0409.pdf.

- The OSHA Office of Regulatory Analysis estimated a return of $4 to $6 for every $1 invested in workplace safety and health.[8]
- The Consumer Product Safety Commission's Directorate for Epidemiology reported an average of 41,500 residential fires involving electrical distribution systems from 1990-1998. They estimated the average total cost of electrical fires in the U.S. is about $2.36 billion a year.[9]
- Safe design includes energy conservation issues and power dependency such as the criticality of power, work delays with power system repair or replacement, and back-up power dependability.
- For all occupational injuries, the perceived average estimated ratio of direct costs to indirect costs was 2.12 based on senior management survey results from a variety of companies with 100 or more employees.[10]
- However, indirect costs for electrical injuries may be much greater. Direct costs were multiplied by 8.25 in one study to obtain total cost of electric injuries in the electric industry.[11]
- Using the 8.25 multiplier, $18.1M possible annual DoD savings per year.

DoD OWCP Chargeback Costs for Electricity Cases
Number of cases= 1264
Period Covered: 1994 – 2011

Service	Total Chargeback Amounts	Total Number of Cases	Average Chargeback per Case
Navy	$17,299,594	656	$26,524
Air Force	$10,946,106	215	$50,912
Army	$ 7,420,641	312	$23,784
DOD Agencies	$ 1,680,529	81	$20,747
Totals	$37,446,870	1264	

Chargeback amounts include costs associated with death payments to survivors, compensation, medical costs, periodic roll, and scheduled awards.

Indirect costs associated with DoD claims reported due to electricity are not accounted for in this table.

Notes:

a) The Office of Worker Compensation Program mishap cost data is only for DoD civilians, and do not include costs for damaged equipment or mishap indirect costs such as per case disability costs which can last for decades.

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[8] OSHA Safety and Health Management e-Tool retrieved from: https://www.osha.gov/SLTC/etools/safetyhealth/helpfulstatistics.html and ASSE Position Statements White Paper *Addressing the Return on Investment for Safety, Health and Environment Management Programs*: http://www.asse.org/professionalaffairs_new/positions/roi.php.

[9] Consumer Product Safety Commission Memo dated March 10, 2003, Economic Considerations for AFCI Replacements: http://www.cpsc.gov/PageFiles/102325/ecafci.pdf.

[10] ASSE Professional Safety (April 2009) *Financial Decision Makers' View on Safety*: http://www.asse.org/practicespecialties/bosc/docs/F2_Huangetal_0409.pdf.

[11] New York Academy of Sciences, *Health Implications of Global Electrification* (1999).

b) No injury cost information is available for the military.
c) Based on data for injury costs from the utility industry, OWCP chargeback appear under-reported and may not include all injuries, for example electric burns which may not be coded as an electrical injury.[12]

Designs for Reducing the Likelihood of Injury from Electrical Hazards - Estimated Costs

1) Engineering design study for the coordination of relay and circuit breaker settings: estimate is $75,000/facility.[13]
2) High resistance grounding is based on system requirements estimate is $125,000/ location.[14]
3) Covered or isolated bus: Costs could vary greatly depending on the electrical system configuration and would generally require an electrical inspection.
4) Current limiting fuses and current limiting breakers: Costs vary and require engineering short circuit analysis, coordination and incident energy study. Cost of analysis is estimated to be between $20K and $200,000 per installation.[15]
5) Touch proof equipment.[16] Costs depend on the need to perform energized work, the number and location of exposed energized conductors, maintenance, inspection and troubleshooting. IEC 60529 IP4X enclosure cost is $350 to $2,000.[17]
6) Remote operation of equipment.[18]
7) Arc resistant enclosures: Costs depend on voltage, incoming current, short-circuit interrupting capacity, other installation-specific requirements (i.e., indoors, outdoors, temperature conditions, etc.), and any dimensional restrictions. Price can vary greatly from $20K up to millions.[19]

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[12] M. Capelli-Schellpfeffer, *The Business Case for Electrical Safety*, November 28, 2011.
[13] Source: Quadrelec Engineering Corporation, Protective Device Coordination Studies: http://www.quadrelec.com/pages/studies_protective.html
[14] Source: Siemens Corp., retrieved from: http://w3.usa.siemens.com/us/internet-dms/btlv/ElectricalApparatus/Switchboards/Switchboards/LV_High_Resistance_Grounding.pdf
[15] Personal communication, August 23, 2013 with Chris Simonson, Emerson Electrical Reliability Services, Atlanta.

[16] Electrical Installation Equipment Manufacturers' Association, *A Guide to the IP Codes for Enclosures Degree of Protection*: http://www.cameuk.com/camenew/tech-docs/08_Misc%20drawings%20and%20diagrams/IPCodes.pdf.
[17] Reference Automation Direct: http://www.automationdirect.com/adc/Shopping/Catalog/Enclosures/Non-Metal_(NEMA_4X_-a-_3R)/Control_NEMA_4X_(30_in._X_20_in._to_60_in._X_36_in.)#
[18]EATON Remotely operated switchgear: http://www.eaton.com/Eaton/ProductsServices/Electrical/ThoughtLeadership/Safety/RemoteRackingandControl/index.htm; Schneider Electric remote racking, CBS Arc-Safe Remote Racking Systems: http://www.cbsarcsafe.com/remote-racking-videos.htm.

[19] 30 August 2013 personal communication with Edwin Vasan, AZZ Inc., Canada Sales Manager EdwinVasan@azz.com, www.azz.com, manufacturer information: http://www.azz.com/sites/default/files/documents/BSL%20Brochure_1.pdf

8) Arc detection and suppression systems.[20]
9) Withdrawable motor control center.[21]
10) Ground Fault circuit interrupters cost is $25-$100/GFCI.
11) Arc fault circuit interrupters: Data from the National Fire Incident Reporting System and the NFPA showed that electrical arcing caused about 48,800 fires annually in dwellings from 1994-1998. The use of AFCIs in residences may significantly decrease the massive costs these fires.[22] The Consumer Product Safety Commission (CPSC) estimates that 50-75% of electrical fires could be prevented by AFCI technology. CPSC estimated the total benefits of arc fault circuit interrupters are almost double the expected costs.[23]
12) Smart motor control center is $12,500 in one case.[24]
13) Inspection viewports: UL-approved device for closed-door inspections.[25]

Electrical Safety at Risk DoD properties[26]

The DoD manages a worldwide real property portfolio that spans all 50 states, seven U.S. territories, and 40 foreign countries. The majority of the foreign sites are located in Germany (232 sites), Japan (109 sites), and South Korea (85 sites).

Total Number of DoD sites worldwide by Service:
Army: 2,214
Navy: 944
Air Force: 1,762
MC: 155
Washington HQ Services (WHS)/Agencies: 136

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[20] Arc Suppression Technologies, NOsparc™ devices: http://www.arcsuppressiontechnologies.com/. Data sheet: http://www.onlinecomponents.com/datasheet/mmxac.aspx?p=43525846&Resource=1.
[21] EATON: http://www.eaton.com/EatonCom/ProductsServices/Holec/Products/LowVoltageFactoryAssembledSwitchboards/PowerXpertCX/PCT_252383.
[22] Reference: National Association of State Fire Marshals Science Advisory Committee *Recommendations Regarding Arc-Fault Circuit Interruptors to Prevent Fires Originating in Electrical Wiring*: http://www.firemarshals.org/pdf/Doc.pdf.
[23] Consumer Product Safety Commission Memo dated March 10, 2003, Economic Considerations for AFCI Replacements: http://www.cpsc.gov/PageFiles/102325/ecafci.pdf.
[24] Source Siemens: http://www.myprocessexpo.com/sites/myprocessexpo.com/files/Kendall_ARC_and_SMART_MCC_090811.pdf.
[25] Mikran Infrared, Inc. *Infrared Inspections of Electrical Cabinets*: http://www.geothermltd.co.uk/downloads/spyglassviewports.pdf.

[26] FY2012 DoD Base Structure Report, Summary of DoD Real Property Inventory http://www.acq.osd.mil/ie/download/bsr/BSR2012Baseline.pdf

Total: 5,211 **(**4,451 in U.S.)

Total Buildings: 298,897 less 30,387 family housing units owned and 7,635 leased.

U.S. Number of large and medium sites:
Army: 72
Navy: 53
Air Force: 75
MC: 13
WHS: 1
Total CONUS large and medium size DoD installations: 214

Estimated costs for engineering design studies for the coordination of relay and circuit breaker settings at large and medium size sites

U.S. DoD large and medium size sites

1. Army: 72 sites X $65,000/site = $4,680,000
2. Navy: 53 sites X $65,000/site = $3,445,000
3. Air Force: 75 sites X $65,000/site = $4,875,000
4. MC: 13 sites X $65,000/site = $4845,000
5. WHS: 1 site X $65,000/ site = $65,000
   Total CONUS: $13,910,000

US Territories Total: 4 sites
4 facilities x 75,000/facility = $300,000

Estimated costs for coordination studies overseas for DoD large and medium sites

6. Army: 13 sites X $75,000/site = $975,000
7. Navy: 7 sites X $75,000/site = $525,000
8. Air Force: 14 sites X $75,000/site = $1,050,000
9. MC: 5 sites X $75,000/site = $375,000
   Total OCONUS: $2,925,000

Total coordination study worldwide for large and medium sites: $17,135,000

Total possible annual savings for electrical injury: $18.15M
($2.2M/year x 8.25, using 8.25 multiplier[27]).

<u>Fires</u>

- 16,742 Electrical fires reported from NFIRS, 2005-2009.

[27] Source: EPRI (1999), *Health Implications of Global Electrification*.

- Total property damage information is unavailable.
- $10M property loss in 2007 from single overheated electrical motor fire.[28]

Replacement Value Factors for Damage/Destruction by Fire
= Facility Quantity[1] X Construction Cost Factor[2] X Area Cost Factor[3] X Historical Records Adjustment [4] X Planning and Design Factor[5] X Supervision, Inspection and Overhead[6] X Contingency Factor[7]

Footnotes:
1: Quantity of assets from the real property inventory database.
2: Construction cost as published in the DoD Cost Factor Handbook
3: A geographic location adjustment for costs of labor, material, and equipment.
4: An adjustment to account for increased costs for replacement of historical facilities or for construction in a historic district; the current value of the factor is 1.05.
5: A factor to account for the planning and design of a facility; the current value of this factor is 1.09 for all but medical facilities and 1.13 for medical facilities.
6: A factor to account for the supervision, inspection, and overhead activities associated with the management of a construction project; the current value of the factor is 1.06 for facilities in the continental US (CONUS) and 1.065 for facilities outside of the continental US (OCONUS).
7: A factor to account for construction contingencies; the current value of the factor is 1.05.[29]

Comparison of fatal electrical mishap rates per 1 million inhabitants in select countries, 1978[30]

1.	Australia	5.61
2.	Hungary	5.25
3.	Italy	4.92
4.	**U.S.**	4.51
5.	Spain	4.41
6.	Austria	3.20
7.	New Zealand	3.17
8.	France	3.11
9.	Canada	2.90
10.	Ireland	2.80

[28] Capelli-Schellpfeffer, *The Business Case for Electrical Safety*, November 28, 2011.
[29] FY2012 DoD Base Structure Report Summary of DoD Real Property Inventory http://www.acq.osd.mil/ie/download/bsr/BSR2012Baseline.pdf
[30] New York Academy of Sciences, Health Implications of Global Electrification (1999): http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1999.tb07936.x/abstract?systemMessage=Wiley+Online+Library+will+be+disrupted+on+31+August+from+10%3A00-12%3A00+BST+%2805%3A00-07%3A00+EDT%29+for+essential+maintenance&userIsAuthenticated=false&deniedAccessCustomisedMessage=

11. Germany	2.79
12. Belgium	2.64
13. Switzerland	2.21
14. Sweden	2.17
15. UK	1.97
16. Japan	1.50
17. Netherlands	1.29
18. Finland	1.05
19. Norway	0.98
20. Denmark	0.59